Mural aortic thrombi: An important cause of peripheral embolization

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Purpose: **Arterial thromboembolism in patients with an unknown source of embolization is still associated with significant morbidity and mortality. The advent of transesophageal echocardiography (TEE) and magnetic resonance imaging (MRI) and the more frequent use of computed tomography (CT) have led to the identification of mural aortic thrombi (MAT) as a source of distal embolization in a much higher proportion of patients than previously appreciated. The incidence, diagnosis, and treatment of patients with MAT is reported.**

Methods: **In a prospective study, from January 1996 to December 1998, 89 patients with acute embolic events underwent an extensive diagnostic workup, consisting of TEE, CT, or MRI, to detect the source of embolization. Patients in whom the heart (n = 51), occlusive aortoiliac disease (n = 16), or aortic aneurysms (n = 12) was identified as the source of embolization were excluded.**

Results: **Five female and three male patients, with a median age of 63 years (range, 35 to 76 years), with bilateral or repetitive embolic events resulting from MAT were identified, representing 9% of all patients with arterial thrombembolism. All patients had several risk factors for atherosclerosis, but only one young patient had a single risk factor that promoted thrombosis. Successful percutaneous catheter aspiration embolectomy was performed in six patients. The remaining two patients underwent surgical thromboembolectomy. A below-knee amputation had to be performed in two patients, thus representing a morbidity of the primary treatment of 25%. MAT of equal value were detected in the ascending (n = 1) and thoracic aorta (n = 3) by means of TEE, CT, or MRI. MAT in the abdominal aorta (n = 4) were identified by means of CT and MRI. Surgical removal of MAT was performed in seven patients by means of graft replacement of the ascending aorta (n = 1), open thrombectomy of the descending aorta (n = 2), and thrombendarterectomy of the abdominal aorta (n = 4), without intraoperative or postoperative complications. No recurrence of MAT occurred during a median follow-up period of 13 months (range, 4 to 24 months).**

Conclusion: **MAT represent an important source of arterial thrombembolism. A diagnostic workup of the aorta, preferably by means of CT or MRI, should be performed in all patients in whom other sources of embolization have been ruled out. The ideal therapeutic approach to these patients still awaits prospective evaluation. However, based on our experience, MAT can be successfully treated with a definitive surgical procedure in selected patients, with low mortality and morbidity. (J Vasc Surg 1999;30:1084-9.)**

The heart is still, by far, the predominant source of arterial thromboembolism, cited as the site of origin in 80% to 90% of cases in all reported series.[1] An identifiable noncardiac source of emboli, mostly downstream embolization of mural thrombus from aneurysms of the aortoiliac, femoral, or popliteal arteries, was found in 5% to 10% of patients.[2] In the remaining 5% to 10% of cases, the specific source of an embolus could not be determined.[2]

The advent of transesophageal echocardiography (TEE) and magnetic resonance imaging (MRI) and the more frequent use of computed tomography scanning (CT) have led to the identification of mural aortic thrombi as a source of otherwise unexplained embolic events, including stroke, transient ischemic attack, and peripheral emboli. Thus, the incidence of "cryptogenic" emboli has decreased as diagnostic modalities have improved.[3] Nevertheless, modern

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Fig 1. Magnetic resonance imaging of a patient with peripheral embolic events, revealing a mural aortic thrombus (*arrow*).

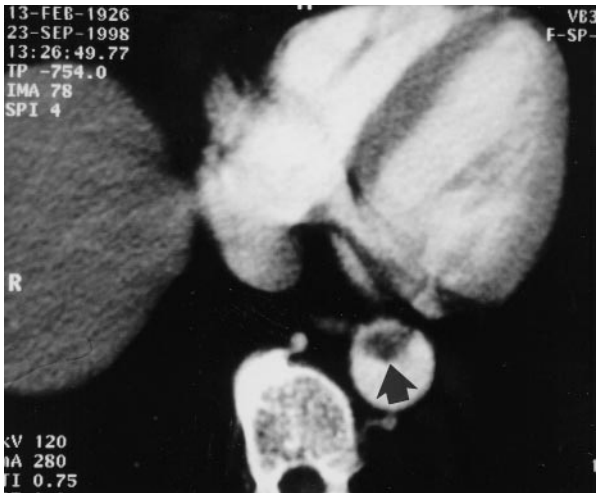

Fig 2. Contrast material-enhanced spiral computed tomography of a patient with peripheral embolic events, demonstrating mural aortic thrombus in the thoracic aorta (*arrow*).

clinical experience indicates that as many as 40% of strokes are still of undetermined cause.[3]

This report details the diagnosis and contrasts the treatment of eight patients in whom mural aortic thrombi were diagnosed as a source of embolization.

MATERIAL AND METHODS

In a prospective study from January 1996 to December 1998, 89 patients with acute arterial thromboembolism, referred to the University Hospital of Bern, underwent an extensive diagnostic workup, including multiplanar TEE, contrast material-enhanced spiral CT, and MRI to detect the source of embolization. Patients in whom the heart, occlusive aortoiliac disease, or aortic aneurysms was identified as the source of embolization were not included in the study. All patients with a cardiac source of embolization diagnosed by means of TEE underwent subsequent CT or MRI to exclude concomitant mural aortic thrombi. Patients with mural aortic thrombi underwent screening for underlying disorders that might promote thrombosis (homocysteinemia, assays for antithrombin III, C1 inhibitor, tissue plasminogen activator, plasminogen-activator inhibitor-1, anticardiolipin antibodies, proteins C and S deficiency, and the fibrin plate assay) and were questioned about whether they had a history of stroke, transient ischemic attack, thrombosis, or previous peripheral embolization.

RESULTS

Five female and three male patients, with a median age of 63 years (range, 35 to 76 years), with embolization resulting from mural aortic thrombi were identified during the study period, representing 9% of all patients referred with peripheral embolization. In the remaining 81 patients, the heart (n = 51), occlusive aortoiliac disease (n = 16), or aortic aneurysms (n = 12) were identified as the most likely sources of embolization. None of the patients with mural aortic thrombi had a history of previous thrombotic or embolic events. The results of screening for diseases promoting thrombosis in these patients were negative, except in one patient who had depressed activation of protein C because of an intermediate hyperhomocysteinemia (69 μmol/L), whereas all patients had several atherosclerotic risk factors (Table I). Four patients were referred with bilateral and one patient with simultaneous peripheral and mild, rapidly regressive clinical signs of cerebral embolization. Immediate treatment after admittance consisted of peripheral percutaneous catheter aspiration embolectomy in six patients and surgical thromboembolectomy in two patients. Three patients had repetitive distal embolic events within hours after interventional therapy, despite full heparinization and no signs of heparin-induced thrombocytopenia, requiring reintervention (Table I). Subsequent below-knee amputation had to be per-

Table I. Patient characteristics, source and site of embolization, risk factors for atherosclerosis, and factors promoting thrombosis

Patient	*Age (years); sex*	*Source of embolization*	*Site of embolization*	*Associated risk factors for atherosclerosis*	*Factors promoting thrombosis*
1	63; man	Abdominal aorta	Lower limbs	Hypertension, nicotine use, chronic renal failure	None
2	70; woman	Abdominal aorta	Lower limbs	Hypertension, nicotine use, diabetes mellitus	None
3	32; man	Abdominal aorta	Lower limbs	Hypertriglyceridemia, nicotine use, hyperhomocysteinemia	Depressed activation of protein C
4	70; woman	Abdominal aorta	Lower limbs	Hypertension, nicotine use	None
5	67; man	Descending aorta	Left lower limb	Hypertension, nicotine use, hypercholesterolemia	None
6	56; woman	Descending aorta	Recurrent embolization right lower limb	Nicotine use, diabetes mellitus, hypercholesterolemia	None
7	75; woman	Ascending aorta	Recurrent embolization upper limb; cerebral embolization	Hypertension, nicotine use, diabetes mellitus	None
8	63; woman	Descending aorta	Recurrent embolization left lower limb	Hypertension, nicotine use, diabetes mellitus, hypercholesterolemia	None

Table II. Diagnostic accuracy of different methods in patients with aortic mural thrombi

Patient	*TEE*	*CT*	*MRI*
1	—	diagnostic	not performed
2	—	diagnostic	not performed
3	—	diagnostic	not performed
4	—	diagnostic	not performed
5	diagnostic	not performed	diagnostic
6	diagnostic	not performed	diagnostic
7	diagnostic	not performed	diagnostic
8	diagnostic	not performed	diagnostic

TEE, Transesophageal echocardiography; *CT,* computed tomography; *MRI,* magnetic resonance imaging.

formed in two of these patients for irreversible ischemic tissue damage, thus representing a morbidity of 25% for the embolic events. Mural aortic thrombi were detected in the ascending aorta (n = 1) and thoracic aorta (n = 3; Figs 1,2) by means of TEE, CT, or MRI, and in the abdominal aorta (n = 4) by means of CT or MRI. Regardless of the locale, all mural aortic thrombi were visualized by means of CT or MRI (Table II). All patients except one patient, who refused further therapy and was lost to follow-up, underwent surgery during the same hospital stay. Surgical therapy included graft replacement of the ascending aorta on extracorporeal circulation in hypothermic cardiac arrest in one patient, posterolateral thoracotomy with subsequent transaortal thrombectomy of the thoracic aorta in one patient, and transabdominal thrombectomy of the main portion of the descending aorta in a female patient with simultaneous chronic occlusion of the celiac trunk and superior mesenteric artery. Intraoperative TEE was used in these two patients as a means of ensuring that the proximal cross-clamp position was above the thrombus. Transabdominal endarterectomy of the abdominal aorta was performed in the remaining four patients. Microscopic sections of the specimen revealed platelet-fibrin thrombi adherent to intimal erosions of variable degrees to atherosclerotic plaques with superimposed thrombi. No intraoperative or postoperative complications occurred in these seven patients. During a median follow-up period of 13 months (range, 4 to 24 months), no recurrence of embolization was noted (Table III). All patients received warfarin postoperatively. Normalization of plasma homocysteine concentration (12 μmol/L) in the patient with hyperhomocysteinemia occurred within 6 weeks after administration of folic acid combined with vitamin B_{12}. CT or MRI was performed in all patients, 12 months postoperatively in six patients, and no recurrence of mural aortic thrombi was shown (Fig 3).

DISCUSSION

During the past decades, several innovative diagnostic and therapeutic techniques have improved the evaluation of patients for arterial embolism, leading to a more frequent diagnosis of mural aortic thrombi, a heretofore rarely identified source of major arterial embolism.[4-10] The incidence of mural aortic thrombi, however, remains unknown. In a pathologic study, Flory[11] reported the presence of mural thrombi superimposed on atheromatous plaques in

the aorta in six of nine patients who had arterial embolization and severe atherosclerotic plaques on autopsy. More recently, Machleder et al[4] reported an incidence of 0.45% of nonaneurysmal aortic mural thrombus in 10,671 consecutive autopsies, with 17% of these patients having evidence of distal embolization. The true incidence, however, has to be significantly higher, because it is not uncommon for these mobile components to disappear because of spontaneous or postmortem intrinsic thrombolysis or because they break loose and embolize.

The pathogenesis of aortic mural thrombus formation has not been defined yet, although it differs distinctly from atheroembolism, encompassing a spectrum of severity ranging from thrombus adherent to a macroscopically near-normal aortic wall to that found in large superficial intimal erosions and multiple areas of large ulcerated atherosclerotic plaques, known as "shaggy" aorta.[12] Generalized hypercoagulation or vascular endothelial disorder has been proposed to be the most important etiological factor for aortic mural thrombus formation.[4] The results of screening for thrombosis-promoting disorders were negative, except in the case of one young patient. Additionally, all patients had single thrombi, and there was no concurrent appearance with a cardiac thrombus. Conversely, all patients had several risk factors for atherosclerosis, suggesting that formation of mural aortic thrombi, in most cases, is primarily a localized problem of the aortic wall.

The development and subsequent refinement of TEE has made possible the relatively noninvasive, clear visualization of the aortic arch and the descending aorta. This procedure can safely be done at the bedside, while patients are awake, and with a very low risk for complications.[3] Several studies with TEE have clearly demonstrated the association between protruding atheromas of the transverse aortic arch and neurological events.[7-10] Nonetheless, TEE has some disadvantages, because portions of the aortic arch and the abdominal aorta are not visualized. Additionally, the investigation is not pleasant for most patients, because the local anesthetic spray often wears off toward the end of long investigation and respraying with the probe in situ is difficult. In contrast, MRI is usually well tolerated and is superior to TEE as a means of defining extracardiac structures.[13] Furthermore, MRI and spiral CT have been shown to be more sensitive than TEE as a means of detecting the formation of thrombus in the entire thoracic aorta.[14] Consequently, we suggest that CT or MRI is the ideal tool for the diagnosis, exact localization, and definition of the extent of mural aortic thrombi.

Fig 3. Magnetic resonance imaging of the patient shown in Fig 2 6 months after transaortal thrombectomy, showing no recurrence of the mural aortic thrombus.

The therapy for intraaortic thrombi remains undefined, although there is evidence that patients with the finding of protruding thrombi of the aorta have a high risk of subsequent vascular events.[15] Thus, therapy for these patients should focus on preventing the evolution of mobile lesions and provide protection against the embolic potential of these lesions. Drug therapy to lower blood lipids or calcium antagonists, currently applied to reduce atheromatous growth in the coronary arteries, may eventually reduce such lesions.[16] Anticoagulation may be administered to patients whose atheromas have mobile components, because these components have been proven to be thrombi in a small number of patients and have been noted to disappear during anticoagulation therapy.[17] Moreover, even complete resolution of mural aortic thrombi with continuous warfarin therapy has been described in a small number of patients.[18] However, the risk-benefit ratio for simple anticoagulation therapy needs further evaluation. In addition to the widely known complications of anticoagulation therapy, bleeding into atherosclerotic plaques with plaque rupture and cholesterol embolization have been described.[19,20] Furthermore, anticoagulation therapy may inhibit the protective fibrin layer over an eroded or ulcerated aortic plaque and interfere with the cementing of cholesterol and atheromatous debris by fibrin, thus causing repetitive embolization.[21] The value of antithrombotic agents (ie, aspirin, ticlopidine) or thrombolysis has not been determined yet. In a single case, successful thrombolysis of an aortic arch

Table III. Treatment and outcome of patients with mural aortic thrombi

Patient	*Primary treatment*	*Outcome of primary treatment*	*Treatment of the source of embolization*	*Outcome and follow-up of secondary treatment*
1	Bilateral PCAE	Uneventful	Transabdominal open TEA of the aorta	Uneventful; no recurrence of MAT
2	Bilateral PCAE	Below-knee amputation	Transabdominal open TEA of the aorta	Uneventful; no recurrence of MAT
3	Bilateral PCAE	Uneventful	Transabdominal open TEA of the aorta	Uneventful; no recurrence of MAT; normal plasma homocysteine concentration
4	Bilateral PCAE	Below-knee amputation	Transabdominal open TEA of the aorta	Uneventful; no recurrence of MAT
5	Unilateral PCAE	Uneventful	Refused further treatment	Lost to follow-up
6	2 × unilateral PCAE	Uneventful	Transthoracic open thrombectomy	Uneventful; no recurrence of MAT
7	2 × open balloon embolectomy	Uneventful, rapid regression of neurological symptoms	Graft replacement of the ascending aorta in hypothermic cardiac arrest	Uneventful; no recurrence of MAT
8	2 × unilateral PCAE	Uneventful	Transabdominal aortic thrombectomy	Uneventful; no recurrence of MAT

PCAE, Percutaneous catheter aspiration embolectomy; *TEA,* thromboendarterectomy; *MAT,* mural aortic thrombi.

thrombus in a patient after mesenteric embolism was described.[22] This therapy bears the potential danger that thrombolytic agents could selectively lyse the stalk of pedunculated lesions, releasing the bulk of the lesions into the bloodstream, and thus causing massive embolization.

Surgical therapy (ie, aortic endarterectomy) has been performed successfully in selected patients.[23,24] Antiplatelet agents or warfarin was used postoperatively in these patients, and no recurrence of embolization occurred during follow-up. Similarly, no recurrence of embolization occurred in our patients during a median follow-up period of 13 months. However, the exact risks and long-term results of this procedure are not yet known. The indications for a surgical treatment and the short- and long-term effects of this treatment, compared with those of anticoagulation therapy, have to be evaluated. The principle features of surgical therapy aim to normalize the aortic surface, by means of graft replacement, thrombectomy, or segmental endarterectomy. Increasing experience and sophistication of equipment favors endovascular techniques for specific vascular lesions, such as floating aortic plaques, which can be managed successfully with stent insertion to prevent further peripheral embolization.[25] In our patients with mural aortic thrombi, we felt that stent insertion was too hazardous, first because of the large size of the mural thrombi and second because of the impending risk of embolization during endovascular therapy.

In summary, mural aortic thrombi are an important cause of distal embolization and may represent a relevant segment of the cryptogenic sources of arterial embolization. The technique of choice for the diagnosis of this condition is CT or MRI. Surgical treatment (ie, thrombectomy, endarterectomy, or graft replacement of the involved aortic segment) is recommended in selected patients. The role of simple anticoagulation or thrombolytic therapy still awaits further evaluation.

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